Bur. Ent. and Plant Quar.
Agr. Res. Admin.
U. S. Dept. Agriculture
In cooperation with 11 cotton-growing States

CONFERENCE REPORT

on

COTTON INSECT RESEARCH AND CONTROL
JACKSON, MISSISSIPPI,
NOVEMBER 28-30, 1949

* * * * * * * * * * * *

This is a summary report of the Conference of Federal and State workers concerned with cotton insect research and control, held at Jackson, Mississippi, November 28-30, 1949. It brings together the results of recent research and experience in the control of cotton insects.

The results summarized in this report will aid in the preparation of recommendations that may be issued by State agencies and the U. S. Department of Agriculture on cotton insect control for 1950. The report is being distributed to entomologists, research and extension workers, the insecticide industry, and others interested in cotton production. Copies are not available for general distribution.

No restrictions are placed on the duplication in whole or in part under the following limitation: In quoting this report, material should not be removed from the context. If the report is not reprinted in its entirety, no less than a complete section relating to one material or insect and supplemental statements referred to therein should be copied. No portion of this report should be used for advertising purposes.

This report supersedes the Conference Report on Cotton Insect Research and Control that was held at Baton Rouge, Louisiana, November 8-10, 1948.

Contents

COTTON INSECT RESEARCH AND CONTROL

Introduction

Research and extension entomologists from 11 cotton-growing States and the United States Department of Agriculture participated in a conference at the Walthall Hotel, Jackson, Mississippi, November 28-30, 1949, to review and summarize their experiments and experiences in cotton insect control and to formulate a guiding statement for control recommendations in 1950. After a review of all available information, the report that follows was agreed upon by all the conferees.

Cultural methods as well as the use of insecticides for controlling cotton pests are considered in this report. The use of cultural control methods cannot be too strongly emphasized. It should be recognized that control of cotton insects by the use of insecticides is really supplemental to the adoption of good farm practices. These include such factors as early fall clean-up, seed treatment, early planting, fertilization, use of proper cotton varieties, proper land use, and cultivation. Cultural measures are influenced by climate, soil conditions, fertility, topography, and geographical location.

In addition to recommendations for the use of certain insecticides for the control of cotton insects, the report presents information believed to be of value to industry in planning production programs and to aid State and Federal workers who cooperate with cotton growers in testing some of the insecticides that are still in an experimental stage. It contains some suggestions as to research needs in developing a more effective cotton insect control program. A general statement of plans by which the extension entomologists will aid in bringing the 1950 cotton insect control recommendations for each state to the attention of growers and all other interested groups is included. Control recommendations are presented in a general manner and are not specifically fitted to local needs. It is expected that each State, in preparing recommendations for cotton insect control for 1950, will adapt to its own conditions the information given in this summary.

Policy on Recommendations

Cotton growers spend millions of dollars each year to prevent or reduce the losses caused by the boll weevil and other insects. Fortunately, entomologists and chemists working together have discovered and developed many chemicals or insecticidal formulations that are effective in the control of cotton insects. Formulations are now available that may be used effectively against each of the species of insects and mites that are pests of cotton. To help avoid confusion of recommendations, when selecting insecticide formulations County Agents, other agencies, and cotton

growers should follow the advice and recommendations of the qualified entomologists in their states who are most familiar with their local problems. These are the entomologists in the State Experiment Stations, Extension Services, Plant Boards, Departments of Agriculture, and the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture.

Research entomologists and chemists connected with Federal, State, and commercial agencies are continuing their investigations in the hope of discovering or developing new insecticidal formulations that are superior to those now used. Unfortunately, through the years, there have been put on the market various so-called boll weevil "remedies" that were of little or no value--and even where they had some slight value, they were usually less effective and more expensive than the standard insecticide formulations that had been widely tested by State and Federal agencies. Cotton growers are urged not to risk wasting money experimenting with new and untried materials or mixtures that have not yet been tested by the State or Federal entomologists. Cotton farmers have been persuaded by salesmen to spend much money in purchasing mixtures and machines that have little or no value in increasing the yields or improving the quality of cotton.

It is desirable that the results of research in cotton insect control not be reported to the public nor made a basis for recommendations until they have been made available to other entomologists working in the same field.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to public safety involved in the use of certain materials.

Hazards and Precautions in the Use of Insecticides

The development of the newer synthetic organic insecticides has provided more effective means of controlling insects, but it has also intensified numerous problems, such as hazard to man, animals, and crops. With few exceptions, all insecticides are poisonous to animals and man and because of this they should be used with appropriate precautions.

The factor of immediate toxicity of insecticides to the user, to livestock, and to plants is of great importance. In addition, there is the effect of delayed toxicity due to repeated exposures, of accumulations of deposits in soils, and of residues on treated plants and on adjacent crops caused by drift. Users of insecticides should be thoroughly familiar with these various hazards and should take proper precautions when formulating, packaging, labeling, and applying the materials.

Precautions for the User

In considering the hazards to man, it is necessary to distinguish between the immediate hazards (acute toxicity) and the accumulative effects (chronic toxicity)

Insecticides can poison by being breathed or absorbed through the skin, as well as by being swallowed. Most solvents used in preparing soultions or emulsions are poisonous, and some are inflammable. Research and experience to date indicate that new chlorinated organic insecticides are reasonably safe to man and the higher animals at strengths normally applied for cotton insect control. In concentrated form, some of the chlorinated hydrocarbon insecticides may cause acute poisoning when in contact with the skin or if swallowed accidentally. Also, continued contact with or exposure to such materials may result in an injurious accumulation of the toxic ingredient in the body. Persons engaged in applying these insecticides should therefore avoid unnecessary exposure to them. Wearing a respirator with suitable filter pads is advisable. The hands should be washed thoroughly before eating. After a dusting or spraying operation is complete, and at least once a day when handling or applying insecticides, it is advisable to bathe and change clothes.

The phosphorus compounds, such as parathion and tetraethyl pyrophosphate, are extremely poisonous materials and (if used at all) must be handled with great care.

It is not practicable to set forth here all precautionary measures that should be taken if phosphorus compounds are used. Such information is available through the Bureau of Entomology and Plant Quarantine and basic manufacturers, and all users should be thoroughly familiar with precautions and see that they are followed.

A few of the more important precautions to observe are the avoidance of breathing dusts, sprays, or vapors--especially the concentrates and their vapors. This can best be assured by using a gas mask with a canister designed for organic poisons.

Loading and mixing should always be done in the open. Impervious gloves should be worn if it becomes necessary to handle the materials, but it is best to avoid any unnecessary contact with insecticide sprays as well as dusts. The concentrates are especially dangerous. As soon as possible after the use of phosphorus compounds, exposed personnel should bathe and change clothes.

It is advisable to have at hand in the field a change of clothing, soap and water, and a supply of atropine for emergency

use. Quick action is essential in case any symptoms of poisoning appear. Those directing control operations should be prepared to assume full responsibility for enforcement of adequate precautions.

All empty containers in which insecticides have been packaged should be burned or otherwise destroyed immediately after emptying. Insecticides should always be clearly identified by labels and stored in a place where they are inaccessible to irresponsible persons and to domestic animals.

Both spraying and dusting operations should be done under such conditions and in such a manner as to avoid excessive drift to adjacent fields where animals are pastured or where food crops are grown. Care in preventing drift is also essential because certain varieties of plants and kinds of crops are injured by insecticides. Spillage of insecticides where they might contaminate water used by man or livestock should be avoided. Any excess dusts or sprays, even in small quantities, should be deeply buried.

Equipment used for applying weed killers should not be used for applying insecticides because of danger of crop injury.

Residues in Soils

The effect of insecticides on germination, rate of growth, and flavor of crops may be influenced by type of insecticide, formulation used, soil type, kind of plant, and concentrations of residue in the soil. Information to date indicates that in the amounts and concentrations recommended for the control of cotton insects, no immediate hazard to crops is involved Injury to several crops by higher rates of application of some insecticides on certain soil types has been demonstrated.

Safeguarding Beneficial Forms of Life

Insecticides destroy beneficial as well as injurious insects. Certain materials, particularly toxaphene, are also highly toxic to fish and other forms of aquatic life. It is especially important to use minimum amounts in cases where there would be an unavoidable drift to ponds and streams. In disposing of excess spray or dust materials, or when cleaning dusting or spraying equipment, every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish.

Preventing Bee Losses

Dusting cotton may cause heavy bee losses. Calcium arsenate appears to be the most dangerous insecticide in this respect because field bees may carry it to the hive where it is fed to the developing brood. The

organic insecticides employed for cotton insect control do not reach the brood as does calcium arsenate. Toxaphene appears to be less hazardous to use where bees are working flowers than benzene hexachloride or DDT. Chlordane appears to be more toxic than DDT or benzene hexachloride.

To hold bee losses to a minimum, it is suggested that:

1. Unnecessary dusting be avoided by careful scouting and timing.
2. Cotton growers notify beekeepers before dusting so that bees can be moved. Beekeepers should contact cotton growers before the cotton insect control season begins and request their cooperation. County agents may serve as clearing houses for such notifications. County agents and cotton growers should be given the exact location of apiaries.
3. Beekeepers be kept informed of cotton insect infestations and recommendations for their control. This will enable them to locate bee yards in the safest available places and to know where and when dusting is expected to begin.
4. Dusting be done under good atmospheric conditions and care exercised to avoid drift, particularly into bee yards.
5. Other things being equal, the insecticide be used that will be the least toxic to bees.
6. Cultural control measures be used to reduce the necessity of insecticidal control.

If better understanding and cooperation can be developed between beekeepers and cotton farmers, bee losses can be reduced.

Methods of Applying Insecticides

Dusts

In dusts the new synthetic insecticides are used as diluted toxicants in combination with carriers, such as talcs or clays, or in combination with other insecticides. Too much emphasis cannot be placed upon proper formulations.

Some of the synthetic insecticide formulations available in many areas of the Cotton Belt possess very poor dusting qualities. In some instances research workers have attributed erratic results and poor control of cotton insects to the inferior dusting qualities of the insecticide. The poor physical condition of some of the commercial preparations no doubt accounts for many of the failures experienced by cotton growers.

More information is still needed concerning insecticidal formulations to establish criteria for suitable organic dust mixtures. Some of these are flowability, adherence, density, and particle size. Further research is needed to determine the most desirable carriers.

Although sulfur is not the most desirable diluent from a physical standpoint, it is recommended for use in those areas where red spider mites are usually a problem. Only a properly conditioned grade of dusting sulfur should be used in the formulations.

Sprays

Preliminary tests with several organic insecticides applied in spray form in 1948 for cotton insect control gave promising results. Further tests in 1949 have shown that concentrated sprays of organic insecticides applied with ground equipment and airplanes gave cotton insect control equal to that obtained with dusts. Sprays have a wide range of usage in that they can be applied during most of the daylight hours, even under conditions of relatively strong winds (15 miles per hour). Boll weevil control has been obtained with as little as 0.5 gallon or as much as 10 gallons of spray per acre with the toxicant remaining constant at the recommended rate. Sprays have been successfully applied to cotton for control of the boll weevil, bollworm, pink bollworm, thrips, cotton fleahopper, tarnished plant bug, rapid plant bug, cotton aphid, and various pentatomids. Most of the new organic insecticides can be made into emulsifiable concentrates. On addition of water, these give emulsions suitable for application. Slight foliage burning has been noted in some instances when the emulsion was improperly applied, or poor distribution was obtained.

Oil solutions of insecticides which were commercially available during 1949 have been tested with ground equipment and with airplane application. All of these resulted in an immediately noticeable speckling or burning of the foliage. Some of these solutions, when applied by airplane, resulted in chronic injury which culminated in large areas of the leaf being burned; and in some instances, small areas dropped out and left badly perforated leaves. Tests of experimental oils indicate that the viscosity and volatility of the oil and its aromatic content are the main factors causing the undesirable foliage reaction.

Solvents with the lowest boiling range and aromatic content which will dissolve the toxicant are the most desirable for use in emulsifiable concentrates. Emulsifiers and solvents should be tested for toxicity to the cotton plant and their general suitability determined before they are used in formulations.

In general, the mass median diameter of the spray droplets should range from 100 to 300 microns.

For treatment of seedling cotton in most areas it is suggested that with ground equipment one nozzle per row be used to apply the spray and, as the cotton increases in size, the number of nozzles per row be increased. If nozzles are kept at least 10 inches from the plant, the danger of leaf burn is minimized.

For use in ground equipment, it is essential that spray concentrates be diluted immediately prior to use with not to exceed an equal volume of water, and the diluted emulsion then added to the required volume of water.

As a safety measure, it is recommended that the spray boom on ground equipment be located behind the operator.

For airplane spray application, it is suggested that from one to two gallons of spray containing the recommended rate of toxicant be applied per acre. It is essential to use some method of flagging for best results. in airplane spraying.

For stability in storage and to prevent breakdown of the formulation when metal containers are used, the containers should be lined with some material that will not react with or cause deterioration of the concentrate. The various formulations made by each insecticide formulator should be prepared in such a way that they may be combined with those of any other formulator and form a stable emulsion.

It is suggested that the formulations contain even multiples of the recommended rates per acre of the insecticide whenever possible. The pounds per gallon of each insecticide in the concentrate should be shown on the label.

Insecticides

Aldrin (Compound 118)

Aldrin, the compound referred to in the report of the Baton Rouge (1948) conference as Julius Hyman 118, was used extensively in experiments in Mississippi and to some extent in some other states for boll weevil control in 1949. It was effective when used as a 2.5 percent dust at the rate of 10 pounds per acre and as a spray at the rate of 0.25 pound per acre. Aldrin will also control the cotton fleahopper, tarnished plant bug, rapid plant bug, some species of cutworms, and thrips. In experiments to date, aphids did not build up following its use. Aldrin will not control the bollworm or red spider mites. It is compatible with all of the new organic insecticides recommended for cotton insect control.

Aldrin is very toxic to animals and is extremely hazardous to handle. It should be handled similarly to parathion until the hazards in connection with its use are better understood.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Benzene Hexachloride

Benzene hexachloride will control the boll weevil, cotton aphid, tarnished plant bug, rapid plant bug, cotton leafworm, thrips, southern green stink bug, garden webworm, fall armyworm, cotton fleahopper, and grasshoppers. It will not control the bollworm, pink bollworm, salt-marsh caterpillar, and red spider mites. For this reason, benzene hexachloride alone frequently cannot be successfully employed for over-all cotton insect control. Benzene hexachloride also kills many beneficial insects.

Benzene hexachloride at approximately one-third pound of the gamma isomer per acre (example: 10 pounds of benzene hexachloride dust containing 3 percent of the gamma isomer) is the minimum rate which has consistently given satisfactory control of the insects against which it is effective. The cotton fleahopper has been controlled with one-tenth pound of the gamma isomer per acre. The most common commercial dust formulations containing benzene hexachloride used by cotton growers for boll weevil control contain 3 percent of the gamma isomer and 5 percent of DDT. In areas where red spider mites are a problem, sulfur should be used in the mixture. The insecticide that gives the best control of the pink bollworm and also controls most of the other cotton insects that may be present in the same field is a mixture containing 10 percent of DDT, 2 percent of the gamma isomer of benzene hexachloride, and 40 percent of sulfur applied at the rate of 15 pounds per acre.

When the mixture of 5 percent DDT and 3 percent of the gamma isomer of benzene hexachloride is used, an average of 10 pounds of dust per acre is recommended for control of the boll weevil and other insects, except the bollworm. Where the bollworm is also a problem, the rate should be increased to 15 pounds per acre. Applications should usually be made at four- to five-day intervals until the infestation is brought under control. The use of this mixture destroys natural enemies of the bollworm, and this insect may increase rapidly following a premature termination of a dust program. One application of 15 pounds of the mixture per acre may suffice for "knock out" aphid control. This mixture is also used for the control of the bollworm and is often preferred to 10 percent DDT alone due to the aphid and boll weevil control which can be expected from the mixture.

Sulfur, pyrophyllite, and non-alkaline clays and talcs have been used as satisfactory diluents for benzene hexachloride.

Benzene hexachloride applied as a low gallonage spray control led the boll weevil in field experiments conducted during 1949. It should be applied at a rate of 0.4 pound of gamma isomer per acre. Proper formulation of the emulsion concentrate is necessary to prevent foliage or plant injury.

Further research is needed concerning the accumulation of this insecticide in the soil following applications to cotton and the resultant effects on other crops. Grain sorghum, Irish potatoes, onions, barley, and cowpeas are some of the crops adversely affected by benzene hexachloride.

High temperatures, wind, and convection currents greatly reduce the effectiveness of benzene hexachloride for aphid control. Technical benzene hexachloride has an objectionable odor and is irritating to the eyes and nasal passages.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Calcium Arsenate

Calcium arsenate is an economical and effective insecticide for the control of the boll weevil and the cotton leafworm. It is used at the rate of 10 to 15 pounds per acre for boll weevil and cotton leafworm control; and 12 to 16 pounds per acre will control bollworms if applications are properly timed and infestations are not too heavy. It is usually used undiluted against the above insects; and when used without an aphidicide, an increase in aphid populations often results. Calcium arsenate has excellent dusting qualities, and is recommended as a standard of comparison with organic insecticides against the cotton insects for which it is effective.

Special or low lime calcium arsenate is compatible with organic insecticides. When this is mixed with either benzene hexachloride or parathion both the boll weevil and the cotton aphid may be effectively controlled. When mixed with DDT, it is effective against the boll weevil and the bollworm.

Calcium arsenate in certain light sandy soils is injurious to some crops, especially legumes and oats. It should not be used for cotton insect control in fields where rice may be planted. Drifting of the dust may injure other crops. Calcium arsenate is poisonous and should be handled carefully. Livestock should be kept out of dusted fields. Care should be taken to avoid drift when dusting near pastures, especially when airplanes are used.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Chlordane

Chlordane will control the boll weevil, cotton fleahopper, tarnished plant bug, grasshoppers, and thrips. For the insects against which chlordane is effective, from 0.5 to 1.5 pounds of the technical material per acre is required. Although it kills some weevils in squares and bolls, conflicting results were obtained regarding the practical benefit derived.

In general, the results obtained with chlordane when used at a comparable dosage per acre against the boll weevil were not equal to results obtained with materials usually recommended for cotton insect control. Chlordane did not control bollworms and red spider mites, and, in many instances, these pests increased following its use. When 40 percent sulfur was added to the chlordane dust, red spider mite infestations did not develop. Chlordane failed to control heavy aphid populations. However, injurious aphid infestations did not develop following its use, unless it was mixed with DDT.

The toxicity of chlordane to higher animals is greater than that of DDT. Operators should avoid breathing the dust any more than is absolutely necessary. Contamination of food and feed crops around cotton fields should be avoided.

Little is known regarding possible ill effects on plants from accumulations of chlordane in soils.

See Hazards and Precautions in the Use of Insecticides, p. 4.

DDT

DDT will control the bollworm, pink bollworm, tarnished plant bug, rapid plant bug, cotton fleahopper, and thrips. It will not control the boll weevil, cotton leafworm, red spider mites, cotton aphid, and grasshoppers.

In general, DDT is used as a dust for cotton insect control at concentrations of not less than 5 percent or more than 10 percent, either alone or in admixture with other insecticides, and at rates of 10 to 15 pounds per acre. Bollworm and pink bollworm infestations require the higher rates of application, but the lower concentrations and rates are effective for the other insects named. DDT failed to control thrips at temperatures above 90 degrees F. Emulsion sprays containing 2 pounds of DDT applied at the rate of $7\frac{1}{2}$ gallons per acre gave promising control of the bollworm.

DDT often increases aphid populations to a point where severe damage may occur unless some aphidicide is included. Following the use of DDT as a dust or spray, either alone or in combination, bollworm infestations sometimes occur after treatments are discontinued.

Either sulfur, pyrophyllite, neutral talcs and clays, or other neutral or slightly acid materials may be used in the formulation of DDT mixtures. Alkaline diluents should not be used. DDT is compatible with all synthetic organic insecticides.

DDT is toxic to certain plants such as cucurbits and, if used in excessive quantities, accumulations in the soil may become toxic to others, especially in light sandy soils lacking humus.

In applying DDT, contamination of adjacent crops from drift should be avoided.

Parasites and predators of insect pests are, in general, susceptible to DDT, and biological control is seriously impaired following its use.

DDT is highly toxic to fish and amphibians, and precautions should be taken to avoid the possibility of stream pollution.

Acute toxicity of DDT to man and animals is rather low as compared with the inorganic insecticides now in use on cotton. However, when DDT is repeatedly ingested or brought into contact with the skin it is absorbed and may be stored in the fatty tissues. Injury to liver may also result. Unnecessary exposure of operators should therefore be guarded against.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Dieldrin (Compound 497)

Dieldrin, the product known as Julius Hyman compound 497, was tested against cotton insects in laboratory and extensive field experiments during the 1949 season only. It was highly effective against the boll weevil in either dust or spray formulations at the rate of 0.25 pound per acre. At this dosage it also controlled the cotton fleahopper, tarnished plant bug, rapid plant bug, fall armyworm, variegated cutworm, and thrips.

Somewhat higher dosages appear to be required for some other cotton insects. Laboratory tests with third-instar bollworm larvae indicate that 0.5 pound of the technical material per acre may be required for satisfactory control. In field experiments against light to medium bollworm infestations, 0.4 to 0.5 pound per acre appeared to be satisfactory.

In laboratory tests, 0.5 pound of dieldrin per acre gave satisfactory control of the cotton leafworm, tobacco budworm, and salt-marsh caterpillar.

Dieldrin is not effective against the garden webworm, cotton aphid, and a red spider mite, Septanychus sp. Increased infestations of aphids and red spiders have followed its use in field applications.

On the basis of a single year's results, dieldrin is a very promising organic insecticide for boll weevil control It was found to kill a larger proportion of the weevils developing in squares than any of the other insecticides tested to date. It should be extensively tested by Federal and State agencies under experimental field conditions in 1950.

Dieldrin is highly toxic to mammals. It is readily absorbed through the skin. Skin toxicity is comparable to that of parathion and, since toxic effects may be delayed for several days, extreme precautions should be exercised when handling or applying dieldrin.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Ditolyl Trichloroethane

In laboratory tests, ditolyl trichloroethane was less effective than DDT against the cotton fleahopper, and less effective than toxaphene against the cotton leafworm. Dust concentrations of 5 to 20 percent were ineffective against the boll weevil, bollworm, cotton aphid, garden webworm, salt-marsh caterpillar, and variegated cutworm.

Heptachlor

Laboratory and field tests with heptachlor indicate that it has possibilities in cotton insect control and deserves further field evaluation. Under laboratory conditions a dust containing 2.5 percent of heptachlor compared favorably with a dust containing 20 percent of toxaphene against adult boll weevils, and in addition killed 100 percent of the weevils developing inside of punctured squares.

In similar tests heptachlor was effective against the variegated cutworm and the salt-marsh caterpillar at concentrations of between 2.5 and 5 percent in dust mixtures. It is not outstandingly effective against the bollworm, cotton leafworm, garden webworm, cotton aphid, or red spider mites.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Lindane

Lindane has been selected as the common name for the essentially pure gamma isomer of benzene hexachloride. A spray containing 0.3 pound of lindane with 1.5 pounds of DDT applied at weekly intervals gave good pink bollworm control and promising results against the boll weevil.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Methoxychlor

Dusts containing 10 percent of methoxychlor controlled the cotton leafworm, but lower concentrations gave poor control.

Methoxychlor gave slightly better pink bollworm control than DDT, but a heavy build-up of aphids usually followed its use and it failed to control bollworms. For these reasons it is not being generally used for pink bollworm control.

Methoxychlor is less effective than the insecticides now recommended for the control of the boll weevil, bollworm, cotton aphid, garden webworm, red spider mites, and stink bugs.

Toxicological studies indicate that methoxychlor is less toxic than DDT to warm-blooded animals.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Nicotine

Two percent nicotine in alternate applications of calcium arsenate (the period between nicotine applications not to exceed 8 to 10 days) if properly applied will usually prevent a cotton aphid build-up.

Either two or three percent nicotine in a suitable carrier can be used to "knock out" heavy aphid infestations. At least 0.2 of a pound per acre of free nicotine equivalent should be applied. The source may be either nicotine sulphate or a fixed nicotine in dust form.

Applications of nicotine dust to "knock out" heavy aphid infestations should be applied when the air is calm and preferably when there is no dew on the plants. Complete coverage is essential.

Nicotine is highly toxic to man and animals and should be used with proper precautions.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Parathion

Parathion will control the cotton aphid, red spider mites, garden webworm, and some species of thrips. It gives very little control of the boll weevil, bollworm, and pink bollworm.

Parathion is an extremely dangerous poison and is not recommended for use on cotton in 1950 except where trained personnel or other individuals are in position to assume full responsibility and to enforce proper precautions as prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Sabadilla

Sabadilla dust at 10 percent strength has been found to be effective against the leaf-footed plant bugs. However, it has little residual action and is disagreeable to use. Since there are other more effective materials the use of sabadilla as a cotton insecticide is very limited.

Sulfur

Sulfur has been widely used on cotton for control of red spider mites and the cotton fleahopper. When used in dust mixtures it sometimes has a repressive effect upon aphid populations in some areas. Where red spider mites are likely to be a serious problem, 40 percent or more of sulfur should be included in organic insecticide dusts used on cotton to prevent the development of damaging mite infestations. Properly conditioned dusting sulfur may be used as a diluent for other insecticides when a non-alkaline or an acid carrier is desirable.

Tetraethyl Pyrophosphate (TEPP)

Tetraethyl pyrophosphate, commonly referred to as TEPP, is highly effective as a spray against the cotton aphid. Experiments indicate that applications containing one-half pint of 40 percent tetraethyl pyrophosphate, or its equivalent, per acre effectively control heavy aphid populations. Sprays containing tetraethyl pyrophosphate are known to be effective against the cotton fleahopper, thrips, and certain spider mites, and should be further tested.

Tetraethyl pyrophosphate is highly toxic to warm-blooded animals; therefore, it should be used with extreme care. It deteriorates very rapidly when exposed to moisture or moist air and is incompatible with alkaline materials. The residual toxicity of this chemical is very short.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Toxaphene

Toxaphene, called "chlorinated camphene" in the report of the Baton Rouge Conference (1948), will control the boll weevil, bollworm, fall armyworm, cotton fleahopper, thrips, cotton leafworm, and grasshoppers. Two to three pounds of the technical material per acre, used either as a dust or spray, will satisfactorily control all these pests. Thrips and cotton fleahoppers may be controlled with as little as one-half pound of the technical material per acre.

Where toxaphene was used throughout the season satisfactory supression of the cotton aphid resulted. It will not, however, control heavy aphid infestations. It will not control red spider mites, and its use may result in their increase; therefore, in some areas it is recommended that the dust contain at least 40 percent of sulfur.

Inherent difficulties are encountered in making satisfactory dusts and emulsion concentrates with toxaphene. Processors and mixers are therefore urged to place on the market only formulations suitable for agricultural use.

No economic injury to cotton has been reported from the use of toxaphene. This material can be handled with relative safety to the operator, if proper precautions are taken. Toxaphene is toxic to livestock and poultry, and is very toxic to fish.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Cultural Practices to Aid in the Control of Cotton Insects

Certain cultural practices reduce cotton losses from insect pests and may eliminate and often reduce the need for the use of insecticides. Several of the following practices may be used by any cotton grower. Others are applicable to certain areas and conditions only. Growers should, in addition to following these practices, continue to make careful observations for insects and apply insecticides when needed.

Planting

Reasonably early planting of cotton during a short, uniform period enables the crop to produce maximum growth and fruit before insects multiply and spread from field to field.

Varieties

Prolific varieties of cotton that fruit early and mature quickly may set a crop before the boll weevil and other insects become numerous, especially if other cultural controls are used.

Soil Improvement

Practices, such as fertilization, rotation of crops, and plowing under green manure, tend to offset insect losses. More injury from insects without yield reduction can be tolerated by rapid-growing cotton in rich soil than by cotton growing in poor soil.

Other Host Crops of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of thrips. Thrips breed in onions, potatoes, carrots, and some other crops and later move in great numbers into adjacent or interplanted cotton.

Hibernation Areas

Boll weevils hibernate during the winter in protected areas in and near cotton fields. Clean cultivation to reduce weevil hibernation quarters and planting of winter cover crops to improve the soil and prevent erosion are recommended. Small patches of weeds near fields or along turnrows and fences, or scattered weeds in the cultivated fields or pastures, can be destroyed at a small cost. Such practices are more effective where the cotton acreages are in sizeable blocks rather than in small patches.

Early Stalk Destruction

The destruction or killing of cotton plants by either mechanical or chemical methods, as early as possible before the first killing frost, forces boll weevils into starvation before they go into winter quarters. The result of early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem in the Lower Rio Grande Valley and in other parts of Texas.

Bug-Catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Chemical Defoliation of Cotton As an Aid to Insect Control

Defoliation of cotton with chemicals has a direct relation to cotton insect control. Defoliation of the cotton has been found to cause boll weevils to leave such fields almost immediately. It also reduces the

percentage of locks infested by weevils. Damage to open cotton by heavy aphid populations and late cotton leafworm infestations have been prevented by chemical defoliation.

Proper defoliation checks the growth of the cotton plant and accelerates opening of the bolls. The crop may thus be harvested earlier thereby permitting earlier destruction of the stalks. Where cotton has been defoliated, a much smaller number of weevils were found the following spring. Defoliants can be applied with the equipment that is used for applying insecticides. For best results the cotton plant should be in the first rest period when the defoliant is applied.

Where soil fertility is high or insect control insufficient, cotton plants are rarely in condition for complete defoliation. Further investigations are needed to determine the relationship of chemical defoliation to more effective cotton insect control.

The search for defoliants should be continued especially for one suitable to the arid west and the southwest for use in connection with pink bollworm control. Time of application of defoliants in relation to crop development and other factors should be further investigated.

Cotton Insects

Boll Weevil

The boll weevil, Anthonomus grandis Boh., may be effectively controlled with benzene hexachloride, calcium arsenate, or toxaphene. Benzene hexachloride should be applied at the rate of not less than 0.3 pound of gamma isomer per acre, calcium arsenate at the rate of 7 to 10 pounds per acre, and toxaphene at the rate of 2 to 3 pounds of the technical material per acre. When these insecticides are used for boll weevil control under field conditions, other insect problems have to be considered. Complications involving the cotton aphid, bollworm, and red spider mites may develop when some of these insecticides are used alone at low dosages for boll weevil control.

Dust formulations recommended for general use include the following: (1) benzene hexachloride (3 percent gamma isomer) - 5 percent DDT mixture; (2) calcium arsenate applied alternately with calcium arsenate - 2 percent nicotine; (3) calcium arsenate applied alternately with benzene hexachloride (3 percent gamma isomer) - 5 percent DDT; (4) benzene hexachloride (2 percent gamma isomer) in special low-lime calcium arsenate in alternate applications with calcium arsenate; and (5) 20 percent toxaphene. Dust mixtures containing 10 percent of chlordane and 5 percent of DDT are recommended only in areas where they have given good control. In some areas these mixtures have given erratic results, perhaps due to high temperatures and humidity.

In areas where red spider mites are a factor, dust formulations of organic insecticides should contain at least 40 percent of sulfur.

Spray formulations of emulsifiable concentrates which have given favorable results and which are recommended are: (1) toxaphene at the rate of 2 to 3 pounds of the technical material per acre; and (2) toxaphene and DDT mixture at the rate of 1 to 2 pounds of technical toxaphene and 0.5 to 1 pound of technical DDT per acre.

Control measures directed against the boll weevil should be applied when definite need is indicated. Except where early season control measures are practiced, insecticides should be applied at intervals of four to five days until the infestation is brought under control. Thereafter, the fields should be inspected weekly and subsequent applications made when necessary.

Bollworm

Serious outbreaks of the bollworm, Heliothis armigera (Hbn.), on cotton occur periodically in most states of the Cotton Belt. Causes of outbreaks are complex, some of them being as follows:

1. Changes in cropping systems. Increased acreage of the crops which are hosts of the bollworm, such as alfalfa, grain sorghums and soybeans are being grown. At times these crops may serve as hosts to increase bollworm populations, while at other times they may act as trap crops, depending on the time of planting, dates of maturity of the crop, and seasonal variations.
2. Insecticides. Low populations of natural enemies of bollworms resulting from the use of some insecticides allow outbreaks to develop.
3. Climatic conditions.

The bollworm may be controlled with dusts containing 10 percent of DDT, 5 percent of DDT plus benzene hexachloride (3 percent gamma isomer), 10 percent of DDT plus benzene hexachloride (2 percent gamma isomer), or 20 percent of toxaphene. Calcium arsenate, lead arsenate, and cryolite dusts are less effective. Whenever red spider mite control is also necessary, any mixture containing organic insecticides should include at least 40 percent of sulfur. All dusts should be applied at the rate of 10 to 15 pounds per acre at each application, the amount depending upon weather conditions, the intensity of the infestation, and size of the cotton. Applications should begin when eggs and four or five small bollworms per 100 terminals are found, and should be continued at five-day intervals until the infestation is brought under control.

During 1949, sprays containing toxaphene applied at the rate of 2 to 3 pounds per acre and a mixture containing 2 pounds of toxaphene and 1 pound of DDT per acre gave promising control of the bollworm. The sprays were applied at a pressure of 60 pounds per square inch and at the rate of 7 gallons per acre, using three nozzles per row.

Successful control of the bollworm is dependent upon timeliness of application and thorough coverage of the cotton plant throughout the period of injurious infestation.

Cotton Aphid

Heavy infestations of the cotton aphid, Aphis gossypii Glov., often occur on cotton following the use of certain insecticides to control the boll weevil or some other insects. The aphid infestation is also sometimes severe on seedling cotton.

The following insecticides and combinations are recommended because they are relatively safe to use and will prevent an aphid build-up when properly applied:

1. Two percent of nicotine in alternate applications applied at the rate of 10 to 12 pounds per acre.
2. Mixtures containing benzene hexachloride (one-third pound of the gamma isomer per acre) in every application.
3. Benzene hexachloride (2 percent gamma isomer) in alternate applications with calcium arsenate.
4. Toxaphene at the rate of two pounds of the technical material per acre in every application.

The following materials are recommended to control heavy infestations of aphids:

1. Benzene hexachloride applied at the rate of one-half pound of the gamma isomer per acre.
2. Three percent of nicotine in a suitable carrier applied at the rate of 10 pounds per acre.

Other insecticides which are effective against the cotton aphid, but which are considered too toxic to be recommended generally, include:

1. One percent of parathion in every application of neutral calcium arsenate to prevent aphid build-up, or one percent of parathion in an inert carrier as a "clean-up."
2. One-half pint of 40 percent tetraethyl pyrophosphate or its equivalent per acre as a "knock-out" measure.

Cotton Fleahopper

The cotton fleahopper, Psallus seriatus (Reut.), can be controlled with the following dusts: 10 percent of toxaphene, 5 percent of DDT plus 75 percent of sulfur, benzene hexachloride (1 percent gamma isomer),

or 2 percent of chlordane. When red spider mites are likely to be a serious problem, 40 percent or more of sulfur should be added to organic insecticide formulations. Less effective control of the cotton fleahopper may be obtained with sulfur alone or with a 2:1 mixture of sulfur-calcium arsenate.

In field experiments conducted during 1949, 0.5 pound of DDT, 1 pound of toxaphene, or 0.5 pound of toxaphene plus 0.25 pound of DDT per acre, applied as low gallonage sprays, gave good control of the cotton fleahopper.

In some instances infestations of the cotton aphid develop following the use of DDT dust or spray.

Tetraethyl pyrophosphate at the rate of 0.2 pound per acre gave good control of the cotton fleahopper. However, due to its toxicity, this material is not recommended for general use.

Cotton Leafworm

The cotton leafworm, Alabama argillacea (Hbn.), has been controlled successfully for many years by calcium arsenate, paris green, or lead arsenate. Dust and spray formulations of benzene hexachloride, toxaphene, a mixture of benzene hexachloride and DDT, or a mixture of toxaphene and DDT, are effective in controlling the cotton leafworm.

Cutworms

Cutworm outbreaks may develop in weeds or crops, especially legumes. Cutworms migrate to adjacent cotton or attack cotton planted on land previously in weeds or legumes.

Recommended control measures are thorough seed-bed preparation and use of poison-bran bait. Allow at least three weeks to elapse between the time of plowing under an infested area and the subsequent seeding of the cotton crop. Poison-bran baits containing paris green, sodium fluosilicate, or toxaphene have been found satisfactory. A poison bait consisting of 40 percent of cryolite and citrus meal gives effective control.

Tests have shown that a dust containing 10 percent of DDT, applied at the rate of 10 pounds per acre, or a spray containing 2 pounds of toxaphene, is effective against the variegated cutworm, Peridroma margaritosa (Haw.), and the granulate cutworm, Feltia subterranea (F.).

In limited field tests toxaphene at the rate of 2 pounds per acre controlled the yellow-striped armyworm, Prodenia ornithogalli Guen.

Fall Armyworm

The fall armyworm, Laphygma frugiperda (A. & S.), occasionally occurs in sufficient numbers to damage cotton. Dusts containing 20 percent of toxaphene, benzene hexachloride (3 percent gamma isomer) - 5 percent of DDT - 40 percent of sulfur, 10 percent of chlordane, or 10 and 20 percent of DDT have given good control. Five percent DDT will control small worms. These insecticides should be applied at the rate of 20 pounds per acre. The results obtained from the above materials have varied in different states, therefore local recommendations are advisable.

Garden Webworm

The garden webworm, Loxostege similalis (Guen.), may be controlled on cotton by dusts containing 5 percent of DDT plus benzene hexachloride (3 percent gamma isomer), 20 percent of toxaphene, or 10 percent of DDT. DDT has given better control in sprays than in dusts and is generally less effective than the other two materials. Calcium arsenate may also be used to control the garden webworm, but heavy poundages are required and control is generally less satisfactory than with the new organic insecticides.

Grasshoppers

Sprays or dusts containing chlordane, toxaphene, or benzene hexachloride are rapidly replacing poison baits for grasshopper control in many areas. This is particularly true where grasshoppers must be controlled on lush or dense vegetation.

Benzene hexachloride sprays and dusts usually produce a spectacular kill of the hoppers in a few hours, but results have been erratic and residual effectiveness is limited to one or two days. Chlordane and toxaphene are very effective but are slower in their action. They remain residually effective for 5 to 14 days, however, depending on prevailing environmental conditions.

Dosages usually recommended to control grasshoppers fall within the following ranges:

Benzene hexachloride, gamma isomer.....0.3-0.5 pound per acre
Chlordane.....0.5-1.5 pounds per acre
Toxaphene..... 1.0-2.5 pounds per acre

The lowest dosage rates suggested are effective against newly hatched to half-grown hoppers. The dosage should be increased as the grasshoppers mature or when the materials are applied on partly defoliated plants or on plants that are unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control where treatment of extensive areas is required, particularly in sparse vegetation.

Pink Bollworm

Methods of controlling the pink bollworm, Pectinophera gossypiella (Saund.), include destruction of cotton stalks immediately following the harvest, heat treatment of cottonseed, burning of gin waste, compression of lint, and the application of dust and spray formulations. In South Texas pink bollworm infestations early in any season are in proportion to the number of these insects which survive the period between crops. The longer this period the fewer insects will survive; therefore, the number of overwintering insects may be reduced by destroying cotton stalks at the earliest possible date. The best procedure is to first cut the stalks with a stalk cutter which crushes them to the ground. If the operation is carried out sufficiently early a high mortality of pink bollworms and other cotton insects results from exposure to heat of the sun. The roots should be plowed out promptly and the crop debris plowed under. All seedlings or sprouted cotton plants developing after the plowing should be eliminated before fruiting so as to create a long host-free period between crops. For best results cultural practices should be carried out on an area-wide basis and the cooperation of every cotton grower is needed. It is a matter of record that cultural practices used to control the pink bollworm will also control the boll weevil.

Cotton growers of the Lower Rio Grande Valley of Texas have used the cultural control as outlined above and, over a four-year period, lint production averaged 313 pounds per acre. Over a ten-year period prior to the beginning of this method of control by early stalk destruction lint production there averaged 208 pounds per acre. It is recognized that the increased production resulted largely from boll weevil control and greater productivity of the soil because of improved farming methods. This increase in production during the four-year period amounted to an additional 445,000 bales of cotton with a gross value of $76,000,000.

There is a progressive build-up in the pink bollworm population as the season advances; therefore, every effort should be made to expedite fruiting and setting the crop. The following practices are recommended for hastening the maturity of the cotton and thereby reducing the pink bollworm infestation: heat or chemical treatment of planting seed; early uniform planting of quick maturing varieties; control of the cotton flea-hopper, thrips, aphids, and other insects that delay fruiting; clean cultivation; elimination of late irrigation; and chemical defoliation.

In cold, arid regions, such as the West Texas Area, where the harvest must be completed after frost, as many bolls as possible should be removed by snapping, mechanical harvesting, or by heavy pasturing.

The cotton stalks should be left standing during the winter months, since the highest mortality of hibernating pink bollworm larvae in such areas is obtained in the bolls on standing stalks. Where the stalks are plowed under early in the winter the fields should be winter irrigated as this practice will also reduce pink bollworm survival.

Larvae of the pink bollworm enter mature cotton seeds to feed and to hibernate. To prevent overwintering or spread of the insect, cottonseed are given a heat treatment as a continuous process of ginning in most pink bollworm quarantined areas. In the other areas, cottonseed are heat treated upon arrival at designated oil mills or other treating plants. In the heavily infested areas a second heat treatment is required before movement into other quarantined or free areas. In all pink bollworm quarantined areas gin waste is destroyed promptly by burning, or heat treated for use as fertilizer, and all lint is compressed before it is moved into areas that are free of pink bollworms.

DDT continues to be the best insecticide for control of the pink bollworm. It can be applied either as a dust or as a spray in a water emulsion. At least 1.5 pounds of the technical material should be used per acre in each application, and the interval between treatments should not exceed 7 days.

Dust formulations should contain not less than 10 percent of DDT and should be applied at the rate of 15 pounds per acre. The cotton plants should be thoroughly covered with the insecticide and where airplane dusters are used the swaths should cover approximately 40 feet. Airplanes should not fly more than 8 feet above the cotton for most effective application of insecticides. A low volume tractor sprayer is the most satisfactory means of applying the DDT spray formulations. Not less than 5 gallons of the emulsion should be used per acre in each application and the nozzles should be adjusted so as to obtain good coverage of the plants. Experiments are being conducted to determine the efficiency of concentrated spray applications with airplanes as compared with dust applications.

Aphids and red spider mites may develop when DDT is used alone for pink bollworm control and it is therefore advisable to incorporate other insecticides in the dust formulations to control these pests. The best formulation is a mixture containing 10 percent of DDT, benzene hexachloride (2 percent gamma isomer), 40 percent of sulfur, and a good conditioner such as pyrophyllite or inert clay. In the presence of a heavy boll weevil infestation it may be necessary to increase the gamma isomer content of the benzene hexachloride to 3 percent. Toxaphene can be incorporated with the DDT spray for boll weevil control and it likewise suppresses the build-up of aphids.

Red Spider Mites

At least five species of red spider mites are known to attack cotton. These species apparently vary somewhat in their susceptibility to different insecticides.

Sulfur at the rate of 20 pounds per acre or 1 percent of DN-phenol at the rate of 10 pounds per acre has been effective against red spider mites under certain conditions. However, it has been reported that a strain of red spider mite has developed which is resistant to sulfur. Notwithstanding the variable results obtained, sulfur is perhaps the most effective insecticide which may be safely recommended to control red spider mites on cotton. In areas where these pests are a factor, dust mixtures of organic insecticides used against other cotton insects should contain at least 40 percent of sulfur to retard red spider increase.

Parathion used experimentally has controlled red spider mites to a very high degree.

In laboratory tests, 4 percent of compound 88 R (β-chloroethyl-β-(p. tert. butyl phenoxy)-α- methyl ethyl sulfite), applied at the rate of 10 pounds per acre, has shown promise against red spider mites. Before any recommendations concerning its use are made, this material should be thoroughly tested under field conditions.

Tarnished Plant Bug and Rapid Plant Bug

The tarnished plant bug, Lygus oblineatus (Say), and the rapid plant bug, Adelphocoris rapidus (Say), sometimes cause injury to cotton, but these insects have received comparatively little attention during recent years.

The organic insecticides ordinarily recommended for cotton insect control are effective against these plant bugs. These include: 5 percent DDT; a mixture containing 5 percent of DDT, benzene hexachloride (3 percent gamma isomer), and 40 percent of sulfur; and 20 percent toxaphene. Sprays recommended for control of the cotton fleahopper or the boll weevil are expected to control these plant bugs.

Thrips

Thrips are probably more destructive to seedling cotton than has previously been considered. They have also caused serious damage to fruiting cotton at times. Stands of young cotton are frequently lost or impaired because of thrips, or the plants damaged to such an extent that growth and fruiting may be delayed for some time. Although losses in yield may not occur in all cases, the delay in fruiting may result in a lower price, higher picking costs, and more chances of the crop being damaged by other insects, wind, or rain.

Thrips may be controlled by one-half to one pound of toxaphene per acre, applied in either dust or spray form. A spray mixture consisting of two-thirds of a pound of toxaphene and one-third of a pound of DDT per acre, or a dust mixture containing 5 percent of DDT and benzene hexachloride (1 percent gamma isomer) applied at the rate of 12 to 15 pounds per acre, is also effective.

Tobacco Budworm

The tobacco budworm, Heliothis virescens (F.), was reported infesting cotton in many localities in the Cotton Belt during 1949. The injury it caused was similar to that of the bollworm. Little evidence is available as to the amount of injury caused by this species in relation to that caused by the bollworm. More information is needed on life history, host plant preferences, seasonal and geographical distribution, and susceptibility of the tobacco budworm to the more commonly used insecticides. DDT as recommended for the bollworm may be used to control this insect on cotton.

White-Fringed Beetles

The white-fringed beetles, Graphognathus leucoloma (Boh.), G. peregrinus (Buch.), and G. minor (Buch.), which are pests of cotton and many other farm crops, are known to be present in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee.

Larvae of the white-fringed beetles damage cotton by feeding on the roots of young plants. These insects can be controlled by the use of good cultural practices and insecticides. Good cultural practices recommended include the following:

1. Planting of oats or other small grains in heavily-infested areas.
2. Restrict planting of summer legumes, such as peanuts, soybeans, velvet beans, or other favorable host plants of the adult beetles to not more than one-fourth of the total crop land. These crops should not be produced on the same land more often than once in three or four years.
3. Do not intercrop corn with peanuts, soybeans, crotalaria, or velvet beans. Prevent the growth of broadleaved weeds, such as cocklebur and sicklepod.
4. Improve poorer soils by turning under winter cover crops.

DDT is effective as a soil insecticide for control of white-fringed beetle larvae. Apply 50 percent DDT at the rate of 20 pounds per acre or 25 percent DDT at the rate of 40 pounds per acre evenly to the soil surface as a dust, spray, or mixed with sand, and then thoroughly mix

it into the upper three to four inches of soil. DDT may be used in the drill before planting. Use 50 percent DDT at the rate of 5 to 10 pounds per acre or 25 percent DDT at the rate of 10 to 20 pounds per acre, mixed with sand. This may be applied by hand or by a fertilizer distributor, at or slightly below the depth of seed planting.

Wireworms

Several species of wireworms are associated with cotton. Perhaps the most noticeable damage is caused by the sand wireworm, Horistonotus uhlerii Horn., in South Carolina, Louisiana, and Arkansas. Adults of the tobacco wireworm (spotted click beetle), Conoderus vespertinus (F.), are frequently found on the cotton plant, but the amount of damage caused by the larvae of this species is not known.

Approved crop rotation practices, increased soil fertility, and added humus help to reduce damage to cotton caused by the sand wireworm. Chlordane, DDT, lindane, and benzene hexachloride have shown promise in the control of this and other species of wireworms on other crops. Additional research on the control of wireworms attacking cotton is needed.

Miscellaneous Insects

Cabbage looper, Trichoplusia ni (Hbn.): The cabbage looper and several other closely related species occasionally cause damage to cotton in localized areas. Dusts containing 5 percent of DDT or 10 percent of toxaphene, applied at the rate of 10 pounds per acre, or sprays of toxaphene or DDT as used for thrips control, will give complete control of the cabbage looper.

Corn silk beetle, Luperodes brunneus (Crotch): This insect has been reported as a pest of cotton in localized areas in several states. Little is known about this insect.

Cotton root aphids: Three species of root aphids are known to attack cotton. These are: The corn root aphid, Anuraphis maidi-radicis (Forbes); Trifidaphis phaseoli (Pass.); and Rhopalosiphum subterraneum Mason. So far as is known, injury by root aphids to cotton is confined to the Eastern Seaboard. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant, Lasius niger alienus americanus Emery. Chemical control of root aphids has been directed at control of the cornfield ant by the use of tartar emetic baits. Some of the newer materials are known to be outstandingly effective as soil insecticides for the control of certain subterranean insects and it is suggested that these be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage Since cotton in this stage often shows signs of injury without any evidence

of insects being present, it is suggested that careful examinations be made of the underground portion to determine the possibility of root aphid attack. Ant mounds at the base of seedling cotton plants indicate the presence of root aphids on the roots.

Cotton square borer, Strymon melinus (Hbn.): The cotton square borer occurs throughout the Cotton Belt, but rarely causes economic damage. The injury caused by this insect to squares is often attributed to the bollworm.

Cotton stainer, Dysdercus suturellus (H. S.): The cotton stainer occurs within the continental limits of the United States in Florida only. However, probably due to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No formal work has been reported in recent years on control, but observations indicate that dusts containing 10 percent of toxaphene or benzene hexachloride (1 percent gamma isomer) will control insects of this genus. There are indications that DDT may also be effectice in some areas.

Cowpea aphid, Aphis medicaginis Koch: The cowpea aphid occurs commonly on very young cotton, especially on the cotyledonous leaves. Cotton is not believed to be a true host plant of this species and the insect will not complete a life cycle on the cotton seedling.

Flea beetles: These insects are rarely serious pests of cotton. A 5 percent DDT dust has been found effective.

Grape colaspis, Colaspis flavida (Say): Calcium arsenate and DDT have given satisfactory control of this insect on cotton.

Salt-marsh caterpillar, Estigmene acrea (Drury): The salt-marsh caterpillar can be controlled by toxaphene, applied as either a dust or a spray at the rate of three pounds of the technical material per acre. Laboratory tests indicate that heptachlor, aldrin, and dieldrin may also be effective when applied at rates of between 0.5 and one pound per acre. Field tests with these compounds are needed to establish minimum effective dosages under practical conditions.

Insects That Attack Cottonseed in Storage

Cottonseed rarely becomes infested with insects while in storage if proper sanitary precautions are followed. Cottonseed or seed cotton should not be placed in a bin or room that has not previously been given a thorough cleaning so as to remove all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that have been reported as causing damage to stored cottonseed or to cottonseed meal are the cigarette beetle, Lasioderma serricorne (F.), the Mediterranean flour moth, Ephestia kuhniella Zell., and the Indian-meal moth, Plodia interpunctella (Hbn.). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed.

Parasites and Predators of Cotton Insects

Parasites and predators aid greatly in the control of insect pests of cotton. However, their help cannot always be relied upon and it is usually necessary to use cultural control practices and to spray or dust the cotton with insecticides. Extensive investigations, which have included the importation and colonization in cotton fields of several insect parasites of the pink bollworm, have shown that so far the use of these natural enemies of cotton insects has limitations.

Cotton Insect Surveys

The results of work done in the past few years have shown the value of surveys to an over-all cotton insect control program. Surveys were conducted during 1949 in all of the major cotton-growing states except California, Missouri, and Tennessee. Cotton insect surveys at present are conducted on a cooperative basis by State and Federal agencies. However, more people are being employed each year by business firms, individual farm operators, and others interested in cotton production to determine cotton insect populations. It is important that individuals employed by private interests to make surveys understand the control programs as well as how to make infestation counts. Therefore, State and Federal entomologists should assist in locating personnel that have at least some basic training in entomology to do survey work for private interests. If this is not done, many growers are sure to be misinformed about recommended control practices.

Information obtained through surveys on insect populations has done much to create interest in cotton insect control programs. When survey data are collected, interpreted, and disseminated at weekly intervals, it is helpful to growers, the insecticide industry, entomologists, and all others interested in an effective control program. The extent and intensity of the coverage largely determine the value of surveys. Therefore, it is recommended that cotton insect surveys be placed on a permanent basis and that they be expanded to include all cotton-producing states.

Wherever possible, it is desirable to enlist voluntary field observers to increase the volume of reports received during the active season. Wider dissemination of the information that is compiled is highly desirable.

Extension Plans For 1950

A successful cotton insect control program depends on the full co-operation and support of everyone interested in cotton production. In conducting a well-rounded program, the Extension Entomologists will use every avenue available in executing it.

1. In preparation for control programs, extension entomologists will:
   a. In each State arrange for a meeting of State and Federal entomologists and cotton specialists to outline the 1950 cotton insect control recommendations for their State, coordinating them with the overall cotton production program.
   b. Procure cooperation of bankers, the Production Credit Associations, the Farmers Home Administration, furnishing merchants, and other lending agencies.
   c. Work with manufacturers and distributors for the purpose of maintaining adequate supplies of recommended insecticides and equipment.
   d. Assemble background information and material, such as circulars, leaflets, and posters, giving insect control information.
2. In their educational procedure, extension entomologists will:
   a. Conduct meetings of county agents and other agricultural workers to outline the cotton insect control program.
   b. Hold training schools early in the season for insecticide dealers and custom operators who apply insecticides.
   c. Plan demonstrations to train farm leaders and individual farmers in making cotton insect counts and to teach them insect control methods.
   d. Arrange result demonstrations where they are needed.
   e. Meet with organized groups, such as the Farm Bureau, Civic clubs, cotton processors, and others for the purpose of acquainting them with recommended insect control practices.
   f. Keep county agents supplied with information on insect populations, as shown by results of State and Federal insect surveys.
   g. Issue timely news articles for use in daily and weekly newspapers and the agricultural press.
   h. Prepare material for radio use, arrange for regular programs on cotton insect control, and release results of survey findings.
   i. Release circular letters to county agents, giving them timely information.
3. To evaluate results, extension entomologists will determine the the merits and extent of the control program and of the educational procedure in each State by:
   a. Observing and recording increased yields of cotton.
   b. Determining the number of acres of cotton treated and the amounts of insecticides used.
   c. Determining grower response to the program.

Research Needs

Immediate information is needed concerning:

1. Spray formulations for use in the control of cotton insects:
   a. Solvents and emulsifiers.
   b. Re-evaluation of toxicants and combinations of toxicants.
2. Designs of machinery and equipment for applying sprays and dusts, including aircraft particularly adapted to various agricultural needs.
3. The value of community action in controlling cotton insects.
4. The physiological and phytotoxic reaction of insecticides, with special reference to spray formulations.
5. The interrelationship between vegetation and fruiting of the cotton plant, with special reference to the timing of insecticide applications.

Basic information is needed concerning:

1. The comparative toxicity of different insecticides.
2. Defoliation in relation to the control of cotton insects.
3. The effect of early-season infestations on the subsequent development and yield of cotton.
4. How the insecticides kill.
5. The effect of sublethal dosages of insecticides upon insect reproduction and development.
6. The effect of temperature, humidity, sunlight, rainfall, and air currents upon the effectiveness of insecticides.
7. Improved techniques for testing insecticides.
8. The effects of insecticides upon natural enemies of cotton insects.
9. The effects of insecticides upon soils, plants, livestock, wild life, and man.
10. The possibility of odor and taste contamination of food products by organic insecticides applied for the control of cotton insects.
11. The development of insect resistance to insecticides.
12. Factors influencing the deterioration of insecticides in storage.
13. The effects of insecticides on honey bees and other pollinating insects.
14. The relation of factors, such as coverage, particle size, distribution and residual toxicity of insecticides, to cotton insect control.
15. The effect of ecological factors, cropping systems, natural enemies, cultural practices, and plant nutrition upon cotton insect populations.
16. Possibilities of gearing insect control to mechanical production of cotton.
17. The seasonal development and life histories and habits of the major cotton pests and others that are potentially injurious.
18. Possible insect vectors of cotton diseases.

Conferees at Jackson, Miss., Conference

Entomologists and associated technical workers interested in cotton insects from the Agricultural Experiment Stations, Extension Services, and other state agencies in 11 cotton-growing States and Iowa, the United States Department of Agriculture, and the National Cotton Council of America participated in a Cotton Insect Research and Control Conference at the Walthall Hotel, Jackson, Miss., on November 28, 29, and 30, 1949. The statements in this report were unanimously agreed upon by the 67 conferees listed below.

Alabama

F. S. Arant, Entomologist, Agr. Expt. Sta., Auburn.
W. A Ruffin, Entomologist, Agr. Ext. Serv., Auburn.

Arkansas

Dwight Isely, Entomologist, Agr. Expt. Sta., Fayetteville.
Charles G. Lincoln, Entomologist, Agr. Ext. Serv., Fayetteville.

Florida

J. W. Wilson, Entomologist, Central Fla. Expt. Sta., Sanford.

Georgia

P. M. Gilmer, Entomologist, Ga. Coastal Plain Expt. Sta. and BEPQ, U.S.D.A., Tifton.
Loy Morgan, Asst. Entomologist, Ga. Coastal Plain Expt. Sta., Tifton.
C. M. Beckham, Entomologist, Ga. Agr. Expt. Sta., Experiment.
Minter Dupree, Asst. Entomologist, Ga. Agr. Expt. Sta., Experiment.
E. C. Westbrook, Extension Service, Univ. of Georgia, Athens.

Iowa 1/

H. M. Harris, Head, Dept. Zoology and Entomology, Iowa State College, Ames.
C. C. Blickenstaff, Entomology Dept., Iowa State College, Ames.

Louisiana

C. E. Smith, Entomologist, Agr. Expt. Sta., Baton Rouge.
L. D. Newsom, Asst. Entomologist, Agr. Expt. Sta., Baton Rouge.
Rudolph Strong, Ext. Serv., Baton Rouge.
C. B. Haddon, Superintendent, Expt. Sta., St. Joseph.
W. G. Erwin, Northwestern State College, Natchitoches.

Mississippi

Clay Lyle, Entomologist, Agr. Expt. Sta., State Plant Bd. and Dean, School of Science, State College.
A. L. Hamner, Assoc. Entomologist, Agr. Expt. Sta., State College.
L. C. Murphree, Ext. Entomologist, State College.
T. M. Waller, Agronomist, Ext. Serv., State College.
B. J. Young, V. P. and Prod. Mgr., Delta Pine and Land Company, Scott.

1/ Cotton is not grown commercially in Iowa, but Dr. Harris and Mr. Blickenstaff were in Mississippi and were invited to participate in the Conference.

North Carolina

W. M. Kulash, Entomologist, State Expt. Sta., Raleigh.
Geo. D. Jones, Ext. Entomologist. Raleigh.

Oklahoma

F. A. Fenton, Head, Department of Entomology, Oklahoma A. & M. College, Stillwater
C. F. Stiles, Ext. Entomologist, Okla. A.& M. College, Stillwater

South Carolina

M. D. Farrar, Head, Dept. of Entomology. Clemson.
W. C. Nettles, Ext. Entomologist, Clemson.
L. M. Sparks, Jr., Ext. Specialist, Clemson.
H. G. Boylston, Ext. Specialist, Clemson.

Tennessee

W. W. Stanley, Assoc. Entomologist, Agr. Expt. Sta., Univ. of Tenn., Knoxville.
J. O. Andes, Ext. Spec. in Plant Path. and Entomology, Univ. of Tenn., Knoxville.

Texas

H. G. Johnston, Head, Dept. of Entomology, Texas A.& M.College, College Station.
J. C. Gaines, Entomologist, Agr. Expt. Sta., College Station.
A. C. Gunter, Ext. Entomologist, College Station.
Herman S. Mayeux, Ext. Entomologist, Assoc. County Agent, San Benito.

United States Department of Agriculture

Agricultural Research Administration

Bureau of Entomology and Plant Quarantine

F. C. Bishopp, Asst. Chief, Washington, D. C.
H. L. Haller, Asst. to the Chief, Washington, D. C.
G. J. Haeussler, Div. of Insect Surv. and Info., Washington, D.C.
L. F. Curl, Div. of Pink Bollworm Control Box 2749, San Antonio, Tex.
R. W. Harned, Div. of Cotton Insects, Washington, D. C.
R. C. Gaines, Div. of Cotton Insects, Tallulah, La.
M. T. Young, Div. of Cotton Insects, Tallulah, La.
G. L. Smith, Div. of Cotton Insects, Tallulah, La.
K. P. Ewing, Div. of Cotton Insects, Waco, Texas.
C. R. Parencia, Jr., Div. of Cotton Insects, Waco, Texas.
A. J. Chapman, Div. of Cotton Insects, Brownsville, Texas.
C. A. Richmond Div. of Cotton Insects, Brownsville, Texas.
R. L. McGarr, Div. of Cotton Insects, San Benito, Texas.
F. F. Bondy, Div. of Cotton Insects, Florence, S. C.
L. C. Fife, Div. of Cotton Insects, Florence, S. C.
C. F. Rainwater, Div. of Cotton Insects, College Station. Texas

United States Department of Agriculture--Continued.
Agricultural Research Administration--Continued.
Bureau of Entomology and Plant Quarantine--Continued.
E. E. Ivy, Div. of Cotton Insects, College Station, Texas.
E. W. Dunnam, Div. of Cotton Insects, Stoneville, Miss.
S. L. Calhoun, Div. of Cotton Insects, Stoneville, Miss.
W. R. Smith, Div. of Cotton Insects, Stoneville, Miss.
W. L. Lowry, Div. of Cotton Insects, Stoneville, Miss.
C. S. Rude, Div. of Cotton Insects, Torreon, Mexico.
H. C Young, Div. of Cereal and Forage Insect Investigations, Florala, Ala.
Bureau of Plant Industry, Soils, and Agricultural Engineering
Paul J. Talley, Cotton Division, Stoneville, Miss.
J. E. Hite, Cotton Division, Jackson, Miss.
Office of Experiment Stations
E. R. McGovran, Entomologist, Washington, D. C.
Extension Service
M. P. Jones, Entomologist, Washington, D. C.
Office of Foreign Agricultural Relations
E. J. Hambleton, Entomologist, Washington, D. C.
National Cotton Council of America
Claude L. Welch, Director, Production and Marketing Div., Memphis, Tenn.
Jack Criswell, Educational Specialist, Memphis, Tenn.
Hal Dilworth, Educational Specialist, Memphis, Tenn.

Washington, D. C.
December 16, 1949